CORRESPONDENCE

Comments on "Large Irregularities of Rawinsonde Ascensional Rates Within 100 Nautical Miles and Three Hours of Reported Clear Air Turbulence"

J. K. ANGELL

Air Resources Laboratory, Institute for Atmospheric Sciences, ESSA, Silver Spring, Md.

This interesting paper by Dr. Hodge [1] presents the thesis that variations in rawinsonde ascent rate can be utilized to delineate areas of clear air turbulence. The reader may be interested in a slightly different treatment of these same data (turbulence reports and rawinsonde ascents for November 8–10, 1963), which were made available through the kindness of Dr. Hodge.

Following Dr. Hodge, the rawinsonde ascent rate was estimated at 2000-ft. intervals from the aneroid. The change in ascent rate for successive 2000-ft. layers was compared with the mean ascent rate for the entire flight, and a ratio was formed. These ratios were smoothed by forming overlapping averages of three with respect to height, and then graphed as a function of height. Turbulence reports received from aircraft within 100 n. mi. of the rawinsonde stations were also plotted as a function of height. Linear interpolation between the 6-hourly or 12-hourly soundings permitted an estimation of the variability in ascent rate at the time turbulence was reported. The variability in ascent rate was also determined for those cases in which no turbulence was reported.

Figure 1 shows the results obtained at individual sounding stations. The line connecting the circles represents, as a function of height, the percentage variability in ascent rate at times when no turbulence was reported. The symbols show the value of this same parameter when turbulence of a given category was reported. In accord with Dr. Hodge's table 1, the variability in rawinsonde ascent rate usually *is* greater when turbulence is reported than when no turbulence is reported, although in some cases there is a question as to whether we are dealing with clear air turbulence. Note, however, that at stations such as Washington and New York the distinction is not clear-cut, primarily because the variability in ascent rate in "non-turbulence" cases is anomalously high.

Figure 2 shows the results obtained by averaging the data for the 12 rawinsonde stations. In "non-turbulence" cases the variability in (smoothed) ascent rate increases from 6 percent at 20,000–30,000 ft. to 8.5 percent at 47,000 ft. In the case of light to moderate turbulence the value increases from 8.5 to 10 percent over the same height interval. Thus, these limited statistics suggest that the variability in ascent rate is about one-third again as large when the aircraft report light-moderate turbulence as when they report no turbulence. The limitations of the data are shown by the fact that the variability in ascent rate is greater when moderate turbulence is reported than when moderate-severe turbulence is reported. Averaging the latter results, we may say that the variability in ascent rate is about two-thirds again as large when moderate or moderate-severe turbulence is reported as when no turbulence is reported.

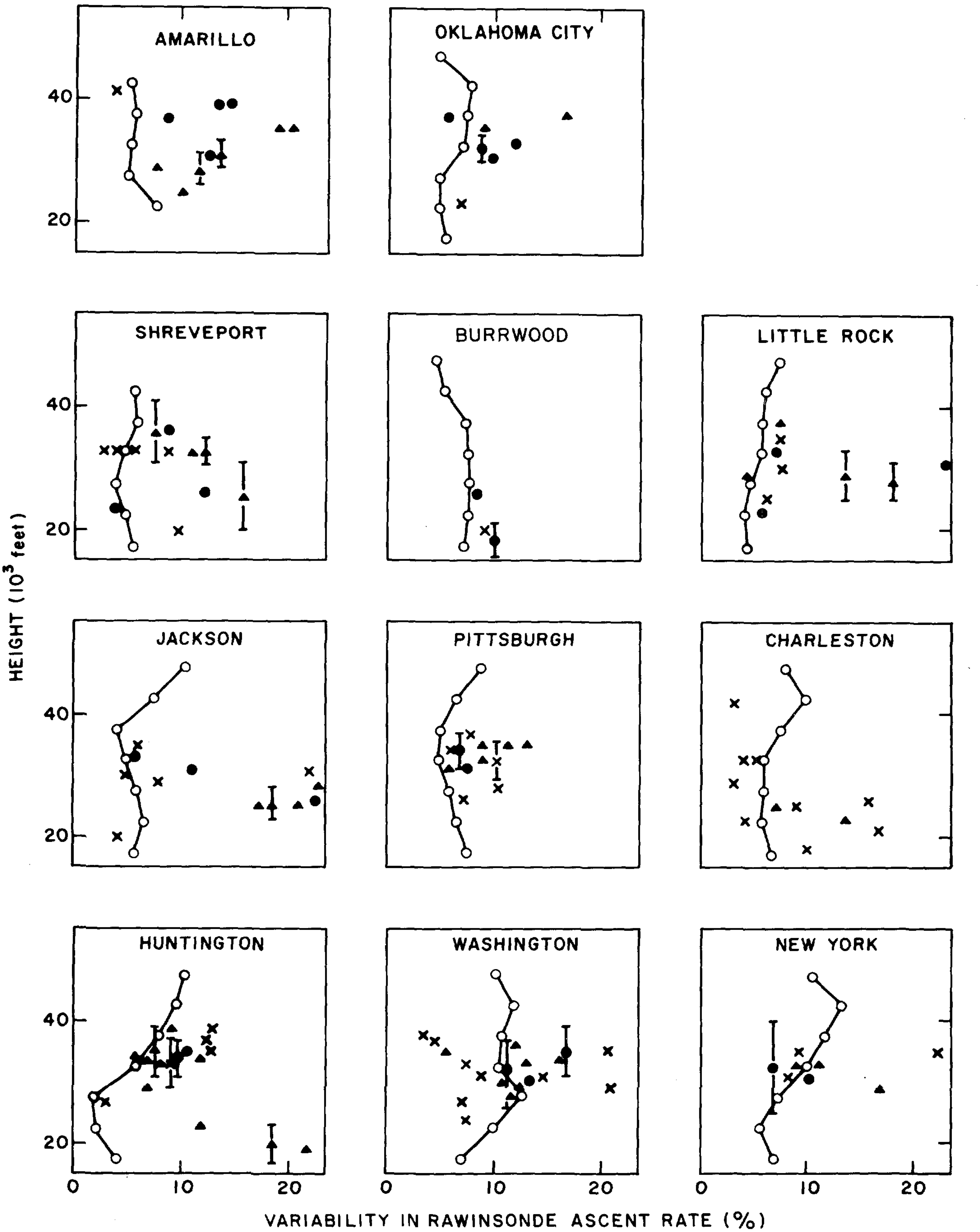

FIGURE 1.—Percent variability in rawinsonde ascent rate as a function of height. The circles connected by lines represent the mean for cases when no turbulence was reported. Crosses, triangles, and dots represent, respectively, cases when light-moderate, moderate, and moderate-severe turbulence was reported by aircraft. Vertical lines through some symbols indicate turbulence reported over a layer.

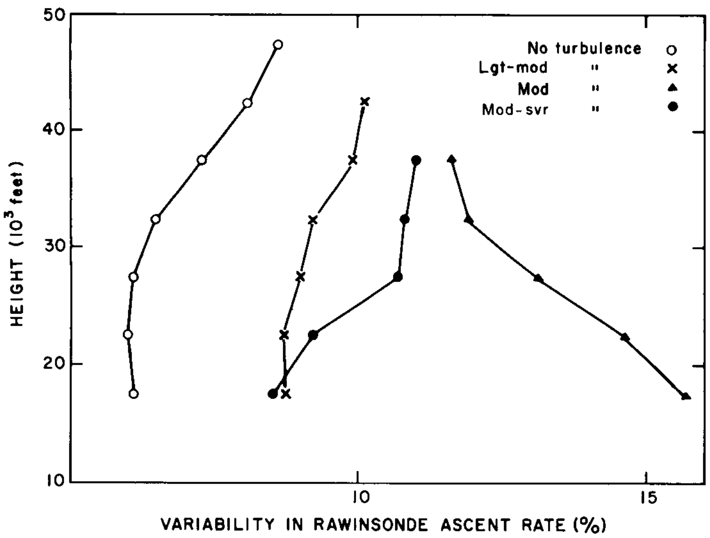

FIGURE 2.—Based on the 12 rawinsonde stations in figure 1, the average variability in rawinsonde ascent rate for cases of "no turbulence" and various categories of turbulence.

Inasmuch as these preliminary results suggest that an in-being observational system may give some clue as to the occurrence of clear air turbulence, I would concur with Dr. Hodge that further studies along this line appear justified. However, these same results suggest that even more useful information could be obtained from a horizontal sounding system. For example, a superpressured, constant-volume balloon with a high drag coefficient would more clearly delineate the vertical air motions involved, and would possess the additional advantage of remaining within the turbulent area for a considerable time. Although there is no doubt that there are difficulties involved in precise radar positioning of such balloons for long time intervals, the constant-volume balloon still seems a logical probe for *research* into the mechanism of clear air turbulence.

REFERENCE

1. Mary W. Hodge, "Large Irregularities of Rawinsonde Ascensional Rates Within 100 Nautical Miles and Three Hours of Reported Clear Air Turbulence," *Monthly Weather Review*, vol. 95, No. 3, Mar. 1967, pp. 99–106.

[*Received April 28, 1967; revised June 14, 1967*]

Reply

MARY W. HODGE

Equipment Development Laboratory, Weather Bureau, ESSA, Silver Spring, Md.

Dr. Angell's letter describes a summarizing technique different from that which I used in table 1 of my paper [1] relating rawinsonde ascensional rate variations to clear air turbulence. I am pleased to have this evaluation and concurring opinion. The ascensional rate computations were those presented in my paper for the 5-day period shown in table 1. The pilot reports furnished Dr. Angell spanned a period ± 6 hr. about the times of the rawinsonde observations, while those presented in my paper were ± 3 hr. about these times.

Dr. Angell states that "in some cases there is a question as to whether we are dealing with clear air turbulence." If he means that some pilot reports of turbulence may have been associated with high-level clouds exclusive of thunderstorm activity he is correct. I treated all pilot reports of turbulence between about 18,000 and 42,000 ft., excluding those within 100 mi. of known thunderstorm activity. A few reports were near high humidity layers which may have been cirrus clouds. It is not uncommon to include these in the category "clear air turbulence." Also, his term "non-turbulence cases" means simply cases in which there were no pilot reports of turbulence. Absence of pilot reports unfortunately does not define non-turbulent cases.

In my opinion, the results of this study do not suggest that more useful information on occurrences of clear air turbulence in time and position could be obtained from a horizontal sounding system than from the vertical sounding system. In fact I would conclude just the opposite. Because of the thin vertical layer in which turbulence occurs and the variable position in the vertical of such layers it would be difficult to place constant-pressure balloons in turbulent layers. With the assumption that turbulent layers had been previously located by aircraft, one possible technique might be to release constant-pressure balloons in these layers from aircraft [2]. Even then it remains for experiment to prove the value of a horizontal sounding system in the study of clear air turbulence.

I wish again to emphasize the outstanding feature of my study. We have data on real time from the rawinsonde observational system which is not now used. If the continuing study shows these data to be useful in locating clear air turbulence they could be made available to weather and aviation interests with little cost and effort compared to establishing a new observational system.

REFERENCES

1. Mary W. Hodge, "Large Irregularities of Rawinsonde Ascensional Rates Within 100 Nautical Miles and Three Hours of Reported Clear Air Turbulence," *Monthly Weather Review*, vol. 95, No. 3, Mar. 1967, pp. 99–106.
2. D. R. Booker and L. W. Cooper, "Superpressure Balloons for Weather Research," *Journal of Applied Meteorology*, vol. 4, No. 1, Feb. 1965, pp. 122–129.

[*Received May 16, 1967*]